Clim. Past Discuss.,
https://doi.org/10.5194/cp-2020-91-SC1, 2020

Climate of the Past Discussions

Interactive comment on "Can we reconstruct the formation of large open ocean polynyas in the Southern Ocean using ice core records?" *by* Hugues Goosse et al.

Ethan Campbell

ethancc@uw.edu

Received and published: 7 September 2020

I want to thank the authors for submitting this fascinating work to Climate of the Past. The journal allows members of the broader scientific community to comment on preprints during the open discussion period. I thought I'd use the opportunity to provide a few brief thoughts, which are not intended to be an exhaustive review.

As someone with a close interest in the Weddell polynya phenomenon (e.g. Campbell et al. 2019), I found this study to be particularly exciting. The techniques used by the authors to identify the fingerprints of past polynyas in ice core records of surface mass balance (among other data) seem well-motivated and promising. Without commenting

Printer-friendly version

Discussion paper

further on the technical aspects of the study, I wanted to share five ideas/suggestions:

1. Meier et al. (2013) analyze recovered Nimbus I satellite imagery and highlight the possibility of a large Weddell Sea opening in 1964 on the basis of a polynya-like feature found in their imagery (see their Fig. 5). It would seem that your reconstructions (Fig. 6b) mostly exclude the possibility of a major, long-lasting polynya in that year. It would be interesting to discuss the relevance of your analysis to their findings.

2. Broecker et al. (1999) speculate that deep convection in Antarctic open-ocean polynyas must have supplied a greater amount of AABW during the Little Ice Age (∼1350-1880) in order to meet present-day PO4* and 14C tracer budgets, with cessation of most open-ocean convection occurring during the post-Little Ice Age transition (possibly 1880-1945, or ongoing). It should be noted that aspects of this interpretation have since been challenged, e.g. by Orsi et al. (2001), who find bottom water ventilation rates from CFCs that seem to agree with those inferred from 14C distributions. There are also some intricacies involving differences in bottom water definitions. Nonetheless, is it possible that your reconstruction could shed some light on the conjecture raised by Broecker and colleagues, as well as their interesting suggestion that "ventilation of the deep Southern Ocean is episodic rather than steady"?

3. To the point in Lines 128-130 that "no high-resolution ocean sediment core that might provide a direct record of polynya activity is available": This unfortunately seems to be the case, as the most promising cores from ODP Sites 689/690 on Maud Rise have rather condensed Pleistocene sections due to low accumulation rates, and are possibly too dry at this point to yield useful samples. However, I anticipate that this study may well motivate future efforts to obtain new polynya proxy records, such as ocean sediment cores from sites with higher accumulation rates at Maud Rise or elsewhere. (I have been thinking about this, as have others!). I wonder if you could comment on how your method and resultant reconstruction of past polynya events from ice core records could complement or inform a similar effort using ocean sediment core records, which would likely cover millennial and longer scales, rather than the decadal-to-centennial

scales examined in this study.

4. I would be interested in seeing Lines 463-466 expanded to discuss alternative ice core chemical proxies in slightly more detail. Past work (e.g. Criscitiello et al. 2013) has attempted to reconstruct coastal polynya variability using sea salt aerosol proxies and is very relevant here. It might be useful to be specific as to which proxies might yield additional constraints on the open-ocean polynya reconstruction.

5. Resplandy et al. (2018) in Nature, cited on Line 79, has been retracted; the re-published version in Scientific Reports is Resplandy et al. (2019).

References:

Broecker, W. S., S. Sutherland, and T.-H. Peng, 1999: A possible 20th-century slowdown of Southern Ocean deep water formation. Science, 286, 1132–1135, doi:10.1126/science.286.5442.1132.

Campbell, E. C., E. A. Wilson, G. W. K. Moore, S. C. Riser, C. E. Brayton, M. R. Mazloff, and L. D. Talley, 2019: Antarctic offshore polynyas linked to Southern Hemisphere climate anomalies. Nature, 570, 319–325, doi:10.1038/s41586-019-1294-0.

Criscitiello, A. S., S. B. Das, M. J. Evans, K. E. Frey, H. Conway, I. Joughin, B. Medley, and E. J. Steig, 2013: Ice sheet record of recent sea-ice behavior and polynya variability in the Amundsen Sea, West Antarctica. J. Geophys. Res. Ocean., 118, 118–130, doi:10.1029/2012JC008077.

Meier, W. N., D. Gallaher, and G. G. Campbell, 2013: New estimates of Arctic and Antarctic sea ice extent during September 1964 from recovered Nimbus I satellite imagery. Cryosph., 7, 699–705, doi:10.5194/tc-7-699-2013.

Orsi, A. H., S. S. Jacobs, A. L. Gordon, and M. Visbeck, 2001: Cooling and ventilating the abyssal ocean. Geophys. Res. Lett., 28, 2923–2926, doi:10.1029/2001GL012830.

Resplandy, L., and Coauthors, 2018: Quantification of ocean heat uptake from changes

in atmospheric O2 and CO2 composition. Nature, 563, 105–108, doi:10.1038/s41586-018-0651-8.

– –, and Coauthors, 2019: Quantification of ocean heat uptake from changes in atmospheric O2 and CO2 composition. Sci. Rep., 9, 20244, doi:10.1038/s41598-019-56490-z.

Interactive comment on Clim. Past Discuss., https://doi.org/10.5194/cp-2020-91, 2020.

Printer-friendly version

Discussion paper